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(71) Applicant: MINNESOTA MINING AND MANUFACTURING COMPANY [US/US]; 3M Center, P.O. Box 33427, Saint Paul, MN 55133–3427 (US).

(72) Inventor: IGNACIO, Ramon, T.; P.O. Box 33427, Saint Paul, MN 55133–3427 (US).

(74) Agents: HOHENSHELL, Jeffrey, J. et al.; Minnesota Mining and Manufacturing Company, Office of Intellectual Property Counsel, P.O. Box 33427, Saint Paul, MN 55133–3427 (US).

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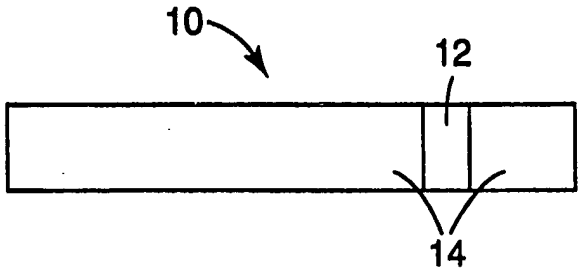
(54) Title: STERILIZATION INDICATOR

(57) Abstract

A sterilization indicator includes a substrate and indicator composition. The indicator composition contains a colorant that undergoes a distinct color change if exposed to hydrogen peroxide vapor. The sterilization indicator can be used to monitor a sterilization process involving hydrogen peroxide vapor.



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STERILIZATION INDICATOR

This invention relates to sterilization indicators.

Background

Medical instruments and parenteral drugs are sterilized prior to use. A traditional sterilization process uses steam under pressure. Alternative sterilization processes use ethylene oxide or hydrogen peroxide in vapor form as the sterilant.

Sterilization indicators are used to monitor whether a sterilization process has been performed. Sterilization indicators may include an indicator composition, carried on a substrate, that changes color during the sterilization process.

Summary of the Invention

The invention features monitoring a sterilization process that uses hydrogen peroxide vapor with a colorant that chemically reacts with hydrogen peroxide. The chemical reaction causes the colorant to undergo a distinct color change during the sterilization process, providing an indication that the sterilization process has occurred. A distinct color change occurs if normal medical professionals can readily discern the color change through visual observation.

Preferably the colorant is a dye such as acid fuchsin. Acid fuchsin changes from purple to colorless when exposed to hydrogen peroxide vapor.

The invention also features a sterilization indicator for use in monitoring a sterilization process involving hydrogen peroxide vapor. The sterilization indicator includes an indicator composition, containing colorant, carried on a substrate such as a polyester strip. The indicator composition optionally may also contain a resin that binds the indicator composition to the substrate.

In addition, the composition optionally may contain a second colorant that does not undergo a distinct color change during exposure to hydrogen peroxide vapor.

The invention also features the indicator composition itself. In addition, the invention features manufacturing the sterilization indicator by printing the indicator composition onto the substrate.

Additionally, the indicator composition may be utilized on sterilization indicator tape.

Other features and advantages will be apparent from the description of the drawing and the preferred embodiment thereof, and from the claims.

Brief Description of the Drawing

The figure is a face plan view of an embodiment of a sterilization indicator.

Detailed Description

The preferred sterilization indicator includes an indicator composition and a substrate.

The indicator composition undergoes a distinct color change when exposed to hydrogen peroxide vapor. Preferably the indicator composition, after incorporation into the sterilization monitor, will exhibit the distinct color change within a certain period of time (e.g., 5 minutes, 15 minutes, or 2 hours) of exposure to an atmosphere containing at least 30% hydrogen peroxide at 45°C. The indicator composition preferably does not undergo fade if left exposed to UV light. For example, the indicator composition preferably will not fade if the sterilization indicator is exposed at a distance of several inches to a standard fluorescent light for one or two days. It also preferably does not revert to its original color when exposed to the air once the sterilization process is complete.

The preferred indicator composition contains a dye that chemically reacts with hydrogen peroxide to undergo a distinct color change. For example, the dye may change, or bleach, from purple to colorless, or from reddish purple to yellow, when exposed to hydrogen peroxide vapor. Examples of dyes that change color in response to hydrogen peroxide vapor include acid fuchsin, basic fuchsin, pinacyanole, ethyl red, and aniline blue.

Enough of the dye should be included in the indicator composition to provide the desired initial color intensity. The quantity of the dye in the composition also will influence the rate at which the composition undergoes the distinct color change. The indicator composition may contain, for example, between 0.05% and 5%, or between 0.1% and 2.5%, of the dye by weight.

Although the dye that undergoes a distinct color change in response to hydrogen peroxide vapor may be the sole colorant in the indicator composition, optionally the composition may also include a second dye that does not change color when exposed to hydrogen peroxide vapors. If the second dye is used in compositions containing a dye that becomes colorless when exposed to hydrogen peroxide, the indicator composition will not fade and become colorless during sterilization, but instead will change from an initial color to the color of the second dye. For example, if the indicator composition contains acid fuchsin, the second dye can be a green dye which in combination with acid fuchsin initially provides the composition with a purple color, but which after the acid fuchsin has become colorless because of exposure to hydrogen peroxide vapor provides the composition with a green color.

A sufficient quantity of the second dye should be included in the indicator composition to provide the targeted color intensity, both prior to and subsequent to exposure to hydrogen peroxide vapor. Too large a quantity of the second dye, for example, may overcome the color of the first dye (pre-exposure to hydrogen peroxide) in the composition. The indicator composition may include, for example, between 0.05% and 5%, or between 0.1% and 2.5% of the second dye by weight.

The indicator composition may contain a resin that binds the composition to the substrate. Examples of binder resins include shellac, ethyl cellulose, hydroxypropyl methylcellulose, methyl cellulose, and ethyl hydroxyethyl ethylcellulose. The shellac can be, for example, bleached bone dry shellac. A sufficient quantity of binder resin should be included in the composition to provide adequate binding of the composition to the substrate.

The indicator composition also may include resins that perform functions other than binding. For example, the composition may include a resin that functions as a dispersing agent that assists in dispersing the ingredients of the composition in the solvent used in application of the composition to a substrate. The composition also may include a resin that makes the composition water resistant once applied to the substrate. Examples of other indicator compositions include acrylic resins.

The binder resin and other resins in the indicator composition may influence the rate at which hydrogen peroxide vapor penetrates into the composition during the, sterilization process. The rate of hydrogen peroxide penetration, in turn, may influence the rate of color change of the composition. As a result, the quantity of total resin used in the composition should be selected to provide the targeted rate of color change. The indicator composition may include, for example, between 20% and 99% of total resin by weight. The resin may be all binder resin, or may be for example, a mixture of binder resin and other resin(s). In the latter situation, the indicator composition may contain, for example, between 30% and 70% of the binder resin by weight, and between 10% and 50% (or 20% and 40%) of the other resin(s) by weight.

The indicator composition may contain other ingredients such as opacifying agents (e.g., titanium dioxide).

Prior to application to the substrate, the indicator .composition is dissolved/dispersed in a suitable solvent (e.g., water or a lower-alkyl (C_1-C_4) alcohol like ethanol or isopropyl). Generally, anywhere from one to two parts of solvent to one part of the indicator composition may be used.

The sterilization monitor preferably can be handled before and after the sterilization process without irritating the skin of the handler. Hydrogen peroxide, particularly at higher concentrations, is an irritant, and thus the preferred substrates are those that do not absorb significant quantities of hydrogen peroxide during the sterilization process. Examples of non-absorbent substrates include polyester, such as Melinex Polyester film. Examples of absorbent substrates include paper substrates, such as blotter paper.

The substrate may be in the form of a strip (e.g., 4.25 x 0.62 inch) having the indicator composition at one end; the other end of the strip then can serve as a grip for the user. When the substrate is an absorbent material such as blotter paper, the grip portion of the strip may be laminated with a plastic outer surface to minimize-the absorption of hydrogen peroxide by the grip during the sterilization process.

The substrate may also have an adhesive on the bottom surface that allows the sterilization indicator to be used as a label. An example of a suitable polyester

label is Copycode WH®, a white polyester with a printable topcoat manufactured by the Fasson Film Division of Avery-Dennison Co.

The indicator composition may be applied to the substrate by any suitable technique. For example, the indicator composition may be applied to the substrate using conventional printing techniques such as flexographic printing or extrusion printing.

Examples 1-5 are examples of sterilization indicators.

Example 1

An indicator composition (in solvent) was prepared that contained the following ingredients:

Ingredient	Quantity	Supplier
Isopropyl Alcohol (Solvent)	300 Grams	---
Acrysol I-545*	150 Grams	Rohm & Haas Co.
Shellac Bleached Bone Dry (V-117**)	150 Grams	Zehrong Corp.
Ethanol (V-117 Solvent)	150 Grams	---
Titanium Dioxide (P-23)	25 Grams	E.T. Horn
Green Dye (DB-892)	3 Grams	Colorcon
Acid Fuchsin	3 Grams	Aldrich Chemical

*Includes water.
**V-117 includes shellac bleached bone dry dissolved in ethanol.

The composition was prepared by combining the isopropyl alcohol and V-117; separately combining the acid fuchsin, the green dye, and the P-23; adding the dye/P-23 combination to the isopropanol/V-117 solution; mixing vigorously; adding the Acrysol I-545; and mixing until homogeneous.

The indicator composition was printed as a stripe on one end of a 4 1/4 x 0.625 inch strip of blotter paper using an extrusion-type printing method. Referring to the Figure, after the solvent evaporated, a sterilization indicator (10) was provided having a stripe portion (12) that includes the indicator composition, and two portions (14) consisting only of the paper substrate. The sterilization indicator was hung inside a 16 ounce jar (with a loose cap) containing 80 ml of

H_2O_2 (31%) at a temperature of 50°C. Initially, portion (12) was purple, but the portion turned green in less than an hour.

Example 2

A sterilization indicator was prepared that included the same indicator composition and substrate described in Example 1, except that (1) basic fuchsin was substituted for acid fuchsin, and (2) the green dye was removed. The sterilization indicator was prepared using the procedure described in Example 1. The indicator composition initially was reddish purple, but when tested according to the procedure described in Example 1 the composition turned yellow within an hour.

Example 3

A sterilization indicator was prepared that included the same indicator composition and substrate described in Example 2, except that pinacyanole was used in place of basic fuchsin. The sterilization indicator was prepared using the procedure described in Example 1. The indicator composition initially was blue, but when tested according to the procedure described in Example 1 the composition turned colorless within 24 hours.

Example 4

A sterilization indicator was prepared that included the same indicator composition and substrate described in Example 2, except that ethyl red was used in place of basic fuchsin. The sterilization indicator was prepared using the procedure described in Example 1. The indicator composition initially was red, but when tested according to the procedure described in Example 1 the composition turned colorless within for 24 hours.

Example 5

A sterilization indicator was prepared that included the same indicator composition and substrate described in Example 2, except that aniline blue was used in place of basic fuchsin. The sterilization indicator was prepared using the

procedure described in Example 1. The indicator composition initially was blue, but when tested according to the procedure described in Example 1, the composition turned light blue within for 24 hours.

The sterilization indicators can be used with commercially available sterilization systems that use hydrogen peroxide vapor. The sterilization process may include, for example, exposure to an atmosphere containing at least 25% hydrogen peroxide vapor for at least 15 minutes. The sterilization process may be conducted at (greater than 40 degrees) elevated temperatures. The sterilization system may use solely hydrogen peroxide vapor as the sterilant, or may use hydrogen peroxide vapor as part of a hydrogen peroxide gas plasma sterilization process. (see, e.g., EP 0 707 186 Al).

For example, the sterilization indicator can be used with the STERRARD® 100 hydrogen peroxide gas plasma sterilization system, which is available from Advanced Sterilization Products, a division of Johnson & Johnson Medical, Inc. The STERRARD®100 can be used to sterilize medical instruments (e.g., fiber optic devices, endoscopic equipment, gloves, linen, parenteral drugs, etc.). The STERRARD®100 utilizes radio waves in hydrogen peroxide vapors to create a gas plasma. Generally, the equipment to be sterilized is placed in the sterilization chamber; the chamber is evacuated; hydrogen peroxide vapor is generated in the chamber and is allowed to diffuse throughout the chamber; the gas plasma is generated; and the chamber is evacuated. If, for example, the sterilization indicator made in Example 1 is placed in the sterilization chamber prior to the cycle, the indicator composition will convert from purple to green during the sterilization process, thereby indicating that the equipment in the chamber has been exposed to hydrogen peroxide vapor.

Other embodiments are within the claims.

What is claimed is:

CLAIMS

1. A method of monitoring a sterilization process including the use of hydrogen peroxide vapor, comprising:

exposing an item to be sterilized and an indicator composition containing a colorant to hydrogen peroxide vapor wherein during said exposure, said hydrogen peroxide vapor chemically reacts with said colorant to cause a distinct color change in said indicator composition.

2. The method of claim 1, wherein said colorant comprises acid fuchsin.

3. The method of claim 1, wherein said colorant becoming colorless after chemically reacting with said hydrogen peroxide.

4. The method of claim 1, wherein said indicator composition is carried on a substrate.

5. The method of claim 4, wherein said substrate comprises a polyester strip.

6. The method of claim 1, wherein said item comprises a medical instrument.

7. The method of claim 1, wherein said item and said indicator composition are exposed to hydrogen. peroxide vapor for at least 15 minutes.

8. The method of claim 7, wherein the concentration of hydrogen peroxide in said hydrogen peroxide vapor is at least 30%-.

9. The method of claim 1, wherein the concentration of hydrogen peroxide in said hydrogen peroxide vapor is at least 30%.

10. A sterilization indicator, comprising: a substrate and, carried on said substrate, an indicator composition that would undergo a distinct color change if said sterilization indicator is exposed to hydrogen peroxide vapor, said indicator composition comprising a binder and a colorant that would chemically react with hydrogen peroxide during said exposure to hydrogen peroxide vapor to cause the distinct color change in said composition.

11. The sterilization indicator of claim 10, wherein said colorant comprises a dye.

12. The sterilization indicator of claim 10, wherein said colorant comprises acid fuchsin.

13. The sterilization indicator of claim 10, wherein said colorant would become colorless during said exposure to hydrogen peroxide.

14. The sterilization indicator of claim 10, wherein said indicator composition further comprises a second colorant that would not change color during said exposure to hydrogen peroxide vapor.

15. The sterilization indicator of claim 14, wherein said colorant that would react with hydrogen peroxide to cause said distinct color change would become colorless during said reaction, and said second colorant would provide said composition with its final color after said exposure.

16. The sterilization indicator of claim 10, wherein said indicator composition, if having undergone said distinct color change, will not revert to its original color.

17. The sterilization indicator of claim 10, wherein said indicator composition will not fade if exposed to fluorescent light for 24 hours.

18. The sterilization indicator of claim 10, wherein said substrate is non-absorbent.

19. The sterilization indicator of claim 10, wherein said substrate comprises polyester.

20. The sterilization indicator of claim 10, wherein said substrate is in the form of a strip.

21. The sterilization indicator of claim 10, wherein said indicator composition would undergo a distinct color change if said sterilization indicator is exposed to an atmosphere containing 31% hydrogen peroxide vapor for 60 minutes at 50°C.

22. The sterilization indicator of claim 10, wherein said sterilization indicator comprises a grip portion including said substrate but not said indicator composition.

23. A sterilization indicator, comprising: a substrate and, carried on said substrate, an indicator composition that would undergo a distinct color change if said sterilization indicator is exposed to hydrogen peroxide vapor, said indicator composition comprising a first colorant that would chemically react with hydrogen peroxide during said exposure to hydrogen peroxide vapor to cause the distinct color change in said composition, and a second colorant which during said exposure to hydrogen peroxide vapor would not change color.

24. The sterilization indicator of claim 23, wherein said first colorant comprises a dye that would become colorless during said exposure to hydrogen peroxide, and wherein said second colorant would provide said composition with its final color after said exposure.

25. The sterilization indicator of claim 23, wherein said first colorant comprises acid fuchsin and said second colorant comprises a green dye.

26. The sterilization indicator of claim 23, wherein said indicator composition, if having undergone said distinct color change, will not revert to its original color.

27. The sterilization indicator of claim 23, wherein said indicator composition will not fade if exposed to fluorescent light for 24 hours.

28. The sterilization indicator of claim 23, wherein said substrate is non-absorbent.

29. The sterilization indicator of claim 23, wherein said substrate comprises polyester.

30. The sterilization indicator of claim 23, wherein said substrate is a strip.

31. The sterilization indicator of claim 23, wherein said indicator composition would undergo a distinct color change if said sterilization indicator is exposed to an atmosphere containing 31% hydrogen peroxide vapor for 60 minutes at 50°C.

32. The sterilization indicator of claim 24, wherein said sterilization indicator comprises a grip portion including said substrate but not said indicator composition.

33. An indicator composition that can be used during a sterilization process using hydrogen peroxide vapor, said indicator composition comprising a first colorant that would become colorless if exposed to-hydrogen peroxide vapor, and a second colorant that would not become colorless during said exposure.

34. The indicator composition of claim 33, wherein said first colorant comprises acid fuchsin.

35. The indicator composition of claim 33, wherein said indicator composition would undergo said distinct color change if said sterilization indicator is exposed to an atmosphere containing 31% hydrogen peroxide vapor for 60 minutes at 50°C.

36. A method of manufacturing a sterilization indicator, comprising:

printing onto a substrate an indicator composition that will undergo a distinct color change if said sterilization indicator is exposed to hydrogen peroxide vapor.

37. The method of claim 36, wherein said indicator composition comprises acid fuchsin.

38. The method of claim 36, wherein said indicator composition would undergo said distinct color change if said sterilization indicator is exposed to an atmosphere containing 31% hydrogen peroxide vapor for 60 minutes at SOOC.

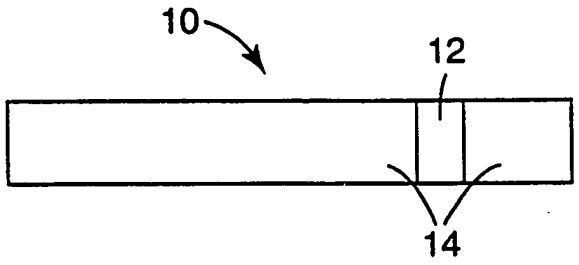

Fig. 1

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 98/10273

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61L2/26 G01N31/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61L G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category ¹	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 139 957 A (GRACK SCOTT J) 18 August 1992 see claims; examples 1-5	1,4
Y	WO 96 33242 A (NORTH AMERICAN SCIENCE ASSOCIA) 24 October 1996 see page 7, line 2-3 see page 16, line 16; claims	1-38
Y	DATABASE WPI Section Ch, Week 7502 Derwent Publications Ltd., London, GB; Class D16, AN 75-02985W XP002078279 & JP 49 046440 B (EIKEN CHEMICAL CO LTD) , 10 December 1974 see abstract	1-38

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 September 1998	01/10/1998

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INTER. .TIONAL SEARCH REPORT

.formation on patent family members

Inter nal Application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5139957 A	18-08-1992	NONE	
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		EP 0821714 A	04-02-1998
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		CA 2129839 A	19-08-1993
		US 5556743 A	17-09-1996
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		CA 2220232 A	19-12-1996
		US 5780098 A	14-07-1998

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/10273

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category '	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 93 16386 A (ACTIMED LAB INC) 19 August 1993 see claims	1-38
A	WO 96 40299 A (MINNESOTA MINING & MFG) 19 December 1996	